<u>AMENDMENTS TO THE SPECIFICATION AND ABSTRACT:</u>

Please replace the original specification and abstract with the enclosed substitute specification and abstract.

OK TO ENTER YB 4/1/04

Sub Spec #6 JF 2-5-4

POLISHING MEMBER AND APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a polishing member used for polishing a substrate to a flat surface. More specifically, the present invention relates to a polishing member providing a polishing surface, such as a polishing pad or an abrasive plate, which exerts a polishing action by slidable engagement with a substrate, such as a semiconductor wafer. The present invention also relates to a polishing apparatus having the above-mentioned polishing member.

A semiconductor device fabricating process comprises forming a thin film layer on a wafer, and forming minute patterns and holes in the layer. This process is repeated until a desired number of circuit layers are formed on the wafer. Consequently, raised and recessed portions are created on or added to a surface of the wafer after formation of each circuit layer. In recent years, semiconductor devices have become increasingly minute and element structures of semiconductor devices have become increasingly complicated. Further, a number of circuit layers in logic type devices has tended to increase. As a result, raised and recessed portions on a surface of a semiconductor device have also tended to increase in number, along with an increase in differences in height between such portions. This leads to a problem in that during formation of a film on a wafer, an extremely thin film is formed over an uneven area on the wafer where such raised and recessed portions exist, and as a result,

breaks in a circuit and electrical insulation defects between circuit layers are likely to occur. This results in a decrease in both yield and quality of a semiconductor product. While a semiconductor device with an inherent weakness, as described above, may initially operate properly, over time, reliability will be lost.

Raised and recessed portions existing on a wafer surface also cause problems in performing lithography processes. Specifically, if a surface for exposure has raised and recessed portions, focusing of a lens of an exposure system becomes difficult, making formation of minute patterns correspondingly difficult.

For these reasons, techniques for use in flattening a surface of a semiconductor wafer while fabricating semiconductor devices have become increasingly important. Various such techniques are known, the most important of which is Chemical Mechanical Polishing (CMP). In this technique, a polishing apparatus having a polishing pad is employed, with the pad being brought into sliding engagement with a wafer to be polished. During sliding engagement, a polishing liquid containing abrasive particles of silica (SiO_2) or the like is supplied to a polishing surface of the polishing pad.

Conventionally, the polishing apparatus of the above-mentioned type comprises a polishing table having an attached polishing pad to provide a polishing surface, and a wafer holder for holding a semiconductor wafer. A wafer holder is adapted to hold a semiconductor wafer and press the wafer against

the polishing table under a predetermined pressure. The wafer holder and the polishing table are moved relative to each other so that the semiconductor wafer is slidably engaged with the polishing surface, to thereby polish the wafer to a flat, mirror-finished surface.

The polishing pad attached to the polishing table comprises a circular non-woven cloth which is formed from foamed polyurethane or fibers bound by using a urethane resin. Generally, the polishing surface, that is, an upper surface of the polishing pad which is slidably engaged with a wafer to be polished, is formed so as to provide an entirely flat surface. In addition to such a flat polishing pad, a polishing pad 60 shown in Fig. 8 having lattice-like grooves 61 formed over its entire surface, and a polishing pad 70 shown in Fig. 9 having dimples 71 formed over its entire surface are also known.

However, use of each of these different pads, namely, the flat polishing pad and the latticed or dimpled polishing pad, gives rise to the following problems. Namely, during a polishing or dressing operation, particles generated from a wafer during polishing, or diamond particles which have become detached from a dresser during dressing are unable to be discharged from the polishing pad and remain on its surface. These wafer particles and diamond particles come into contact with a wafer surface during polishing, and cause scratches therein.

Some of these particles have a relatively large diameter (hereinafter, referred to as "large-diameter particles"); and when these large-diameter particles are in contact with a wafer

surface during polishing, they cause the wafer surface to become separated from the polishing surface by an amount equal to their diameter, and if such particles exist at an edge of a wafer surface, they can cause the wafer surface to become inclined relative to the polishing surface. Consequently, a pressure acting between the wafer surface and the polishing surface becomes non-uniform, which prevents the wafer from being polished uniformly over its entire surface.

Once a polishing operation is complete, the wafer holder applies a vacuum force to the wafer, whereby the wafer is fixed to the holder to be lifted away from the polishing pad. However, in a case where a relatively strong adhesive force holds a wafer to the polishing pad, the wafer holder may fail to separate the wafer and lift it away from the polishing pad. If the wafer remains on the polishing pad while the polishing table is being rotated, the wafer is liable to be damaged.

In view of these problems, the present invention has been made. It is an object of the present invention to provide a polishing member which prevents formation of scratches on a wafer surface during a polishing operation, which ensures a stable polishing performance by engagement between a wafer surface and a polishing member under a uniform pressure, and which enables a wafer to be separated from the polishing member with a high degree of reliability after a polishing operation is complete. It is another object of the present invention to provide a polishing apparatus having the above-mentioned polishing member.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a polishing member providing a polishing surface which exerts a polishing action by slidable engagement with a substrate to be polished, wherein a plurality of spiral grooves are formed in the polishing surface so as to extend from a central portion to an outer peripheral edge of the polishing surface.

The present invention also provides a polishing apparatus comprising a polishing table having the above-mentioned polishing member attached thereto, and a wafer holder adapted to hold a substrate to be polished and press the substrate against the polishing surface of the polishing member on the polishing table.

According to the present invention, a pumping action is produced at the spiral grooves under a centrifugal force generated by rotation of the polishing member, and harmful large-diameter particles such as diamond particles from a dresser and abrasive particles in a polishing liquid can be discharged, together with the polishing liquid, through the spiral grooves toward an outer peripheral portion of the polishing member. This prevents scratches from being formed on a wafer surface, and enables the wafer surface to be engaged with the polishing member under a uniform pressure, thereby obtaining a stable polishing performance.

Further, a polishing liquid in a slurry form can be stably supplied to a wafer surface through the spiral grooves. This further enhances a stable polishing performance.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a polishing apparatus having a polishing member according to an embodiment of the present invention.

Fig. 2 is a plan view showing a detail of the polishing member shown in Fig. 1.

Fig. 3 is a plan view showing a polishing member according to another embodiment of the present invention.

Fig. 4 is a vertical cross-sectional view showing an example of a polishing table.

Fig. 5(a) is a cross-sectional view, taken along line P-P in Fig. 4.

Fig. 5(b) is a cross-sectional view, taken along line X-X in Fig. 5(a).

Fig. 6 is a plan view showing an entire construction of a semiconductor processing apparatus of a so-called dry-in/dry-out type.

Fig. 7 is an elevational view of the semiconductor processing apparatus shown in Fig. 6.

Fig. 8 is a view of a polishing pad having lattice-like grooves formed over its entire surface.

Fig. 9 is a view of a polishing pad having dimples formed over its entire surface.

Fig. 10 is a side cross-sectional view of a turntable having a polishing member according to a further embodiment of the present invention, which polishing member comprises two layers and has spiral grooves.

Fig. 11 is an enlarged view of a portion indicated by A in Fig. 10.

Fig. 12 is a side cross-sectional view of a polishing member according to a further embodiment of the present invention.

Fig. 13 is a polishing member according to a further embodiment of the present invention, which includes passages for connecting adjacent spiral grooves.

Fig. 14 is a side cross-sectional view of a polishing member having an indicator provided therein, which indicator indicates whether a polished state of the polishing member is appropriate.

Fig. 15 is a side cross-sectional view of another example of a polishing member having an indicator provided therein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, embodiments of the present invention are described, with reference to Figs. 1 to 5(b).

Fig. 1 is a perspective view of a polishing apparatus having a polishing member, according to an embodiment of the present invention. The polishing apparatus shown in Fig. 1 comprises a polishing table 5 having a polishing member 1 attached thereto. The polishing member 1 in this embodiment comprises a polishing pad. The polishing apparatus further comprises a wafer holder 10 which holds a semiconductor wafer W as a substrate and presses it against an upper polishing surface 1a of the polishing member 1, and a dresser 20 which dresses the polishing surface 1a. A polishing liquid in a slurry form is

supplied from a polishing liquid supply nozzle 21 to the polishing surface 1a.

With this arrangement, the wafer W is held on a lower surface of the wafer holder 10, and is pressed against the polishing member 1 on the polishing table 5 by the wafer holder 10. At the same time, the polishing table 5 and the wafer holder 10 are rotated, to thereby effect relative movement between the polishing member 1 and the wafer W. In this instance, polishing liquid is supplied from the polishing liquid supply nozzle 21 to the polishing surface 1a of the polishing member 1. The polishing liquid is obtained by, for example, suspending fine abrasive particles of silica (SiO_2) in an alkali solution. Thus, the wafer W is polished to a flat, mirror-finished surface by effecting chemical polishing using an alkali solution and effecting mechanical polishing using abrasive particles.

However, when the polishing surface 1a of the polishing member 1 becomes clogged with particles contained in the polishing liquid, a stable polishing performance cannot be obtained. Therefore, in order to prevent clogging of the polishing surface 1a or regenerate the polishing surface 1a, pure water is supplied from a pure water supply device (not shown) to the polishing surface 1a of the polishing member 1 while the polishing table 5 is being rotated and, at the same time, the dresser 20 is rotated and pressed against the polishing surface 1a, thus maintaining the polishing surface 1a in a desirable state. The dresser 20 is a tool adapted to scrape the polishing surface 1a at a level of microns or clean the polishing surface

1a.

Fig. 2 is a plan view of the polishing member 1 comprising a polishing pad shown in Fig. 1. The polishing member 1 comprises a circular non-woven cloth which is formed from foamed polyurethane or fibers bound using a urethane resin. As shown in Fig. 2, a plurality of (8 in this embodiment) spiral grooves 2 are formed in the polishing surface 1a. Each spiral groove 2 extends clockwise from a central portion to an outer peripheral edge of the polishing surface 1a. A spiral angle of each spiral groove 2 (an angle formed by a line connecting the center of the polishing surface 1a and a starting point of the groove and a line connecting the center of the polishing surface 1a and an end point of the groove, as measured in a direction of extension of the groove) is preferably 90° to 450°, and in this embodiment is set to be 360°, as shown in Fig. 2. A width of each spiral groove 2 is preferably 1 to 3 mm, and in this embodiment is set to be about 2 mm. A depth of each spiral groove 2 is preferably 0.5 to 1.5 mm, and in this embodiment is set to be about 1 mm. The spiral grooves 2 are formed by machining a flat polishing pad, or formed simultaneously when forming a polishing pad in a predetermined form such as a circular form, using a mold.

In the above-mentioned embodiment, the polishing member 1 comprising a polishing pad is used. However, the polishing member 1 may be an abrasive plate comprising fixed abrasive particles, which are bound using a binder and formed into a plate. When the polishing member 1 comprises an abrasive plate, a form of the polishing member 1 and an arrangement of the spiral

grooves 2 are the same as those shown in Fig. 2. Examples of abrasive particles include particles of CeO_2, SiO_2 or Al_2O_3. Examples of binders include a thermosetting resin such as an epoxy resin or a phenol resin, and a thermoplastic resin such as an MBS resin or an ABS resin. The abrasive particles have an average particle diameter of at most 0.5 μm. The spiral grooves 2 are formed in the polishing member 1 comprising the abrasive plate by machining a flat abrasive plate, or formed simultaneously when forming an abrasive plate in a predetermined form such as a circular form, using a mold.

When the polishing member 1 comprises an abrasive plate, pure water or a chemical liquid which contains no abrasive particles is used as a polishing liquid. The chemical liquid contains a surfactant, a pH adjusting agent, a chelating agent, and the like.

In the polishing member 1 of Fig. 2, the spiral grooves 2 extend in a clockwise direction. Therefore, the polishing table 5 (see Fig. 1) is rotated in a counterclockwise direction as is indicated by an arrow in Fig. 2. The polishing member 1 of Fig. 2 is advantageous in the following points.

(1) Prevention of Scratches

In the polishing member 1 having spiral grooves of the present invention, during polishing, a pumping action is produced at the spiral grooves 2 under a centrifugal force generated by rotation of the polishing table 5. Therefore, harmful large-diameter particles, such as diamond particles from a dresser and abrasive particles in a polishing liquid, can be discharged,

together with a polishing liquid, through the spiral grooves in a direction away from a central portion to an outer peripheral portion of the polishing member. Therefore, no foreign matter such as large-diameter particles remain on the polishing surface 1a, thus preventing scratches from being formed on a wafer surface.

Recently, larger wafers having a diameter of 200 to 300 mm have been in demand. With these larger wafers, there is an increase in an amount of foreign matter such as harmful large-diameter particles remaining on a polishing surface. However, conventional polishing members having dimples, lattice-like grooves or concentric circle grooves are unable to exert a sufficient action to discharge a large amount of foreign matter, with a result that scratches are increasingly likely to be formed on a wafer surface. However, in the polishing member 1 having spiral grooves of the present invention, foreign matter such as harmful large-diameter particles can be discharged through the spiral grooves 2, together with polishing liquid; and thus, scratching of wafer surfaces is effectively prevented.

(2) Prevention of Damage to Wafers

A conventional polishing member is problematic in that when a wafer holder is lifted away from the polishing member, there is a possibility that a wafer will remain on the polishing member under a relatively strong adhesive force acting between the wafer and the polishing surface. If the wafer is not removed from the polishing surface, it is liable to be damaged. However, with the polishing member 1 having spiral grooves of the present invention,

the polishing surface 1a is subject to atmospheric pressure acting through the spiral grooves 2 and thus no strong adhesive force acts on a wafer. Therefore, the wafer can be reliably removed from a polishing surface and transferred, without being damaged.

(3) Stable Supply of Polishing Liquid

In the polishing member 1 having spiral grooves of the present invention, a polishing liquid in a slurry form can be stably supplied to a wafer surface during polishing. Therefore, a stable polishing performance can be obtained.

(4) Improvement in Maintenance

The polishing member 1 is not adversely affected by harmful large-diameter particles. Therefore, a life of the polishing member 1 can be increased, and an amount of maintenance can be reduced.

Fig. 3 is a plan view of a polishing member according to another embodiment of the present invention. Polishing member 1 of Fig. 3 includes, in addition to first spiral grooves 2 such as those shown in Fig. 2, a plurality of second spiral grooves 3 which extend in a direction opposite to that of the first spiral grooves 2. In this embodiment, eight second spiral grooves 3 are formed in polishing surface 1a. Each second spiral groove 3 extends in a counterclockwise direction from a central portion to an outer peripheral edge of the polishing surface 1a. A starting point of each second spiral groove 3 is located between starting points of two adjacent first spiral grooves 2. A spiral angle of each second spiral groove 3 is preferably 90° to 450°, and is set

to be 360° in the embodiment of Fig. 3. A width and depth of each of the first and second spiral grooves 2 and 3 are the same as those of the spiral grooves 2 shown in Fig. 2. Thus, the polishing member 1 in this embodiment includes two types of spiral grooves 2 and 3 which extend in opposite directions, and the polishing member can be used for rotation in either a clockwise direction or a counterclockwise direction.

Next, referring to Figs. 4 to 5(b), another example of a polishing table is described. The polishing table shown in Figs. 4 to 5(b) is adapted to be subject to a circular orbital motion. Fig. 4 is a vertical cross-sectional view of the polishing table. Fig. 5(a) is a cross-sectional view taken along line P-P in Fig. 4, and Fig. 5(b) is a cross-sectional view taken along line X-X in Fig. 5(a). As shown in Figs. 4 through 5(b), an upper flange 151 of a motor 150 having a hollow shaft, and a shaft 152 having a hollow structure are connected by bolts. A set ring 154 is supported on an upper portion of the shaft 152 through a bearing 153. A table 159 is fixed to an upper surface of the set ring 154. A polishing table 35 is fixed to the table 159 by bolts 190. A polishing member 1 which comprises a polishing pad or abrasive plate such as that shown in Fig. 2 is attached to an upper surface of the polishing table 35. An outer diameter of the polishing table 35 is set to be at least a value of [(a diameter of a semiconductor wafer W) + 2 "e"], so as to prevent the wafer W from being laterally protruded from the polishing table 35 when the polishing table 35 is subject to a circular orbital motion.

Three or more supporting portions 158, four in the

embodiment of Fig. 4, are arranged in a circumferential direction of the set ring 154 at predetermined angular intervals or ninety degrees, so as to support the table 159. That is, the supporting portions 158 each comprise four recesses 160 and 161 formed in a lower surface of the set ring 154 and a upper surface of a stationary bracket 155 provided under the set ring 154, respectively, which recesses are generally aligned with each other in a vertical direction. Bearings 162 and 163 are attached to the recesses 160 and 161, respectively. As shown in Figs. 4 through 5(b), a supporting member 166 having two shaft members 164 and 165 is supported by the bearings 162 and 163 by inserting respective end portions of the shaft members 164 and 165 into the bearings 162 and 163. A central axis of the shaft member 164 is spaced apart from a central axis of the shaft member 165 by a distance "e". By operating the motor 150, the polishing table 35 is subject to a circular orbital motion along a circle having a radius corresponding to the distance "e".

It is to be noted that a central axis of the motor 150 is spaced apart from a central axis of the shaft 152 through the upper flange 151 by the distance "e". In order to balance a load generated by providing the distance "e" between these central axes, a balancer 167 is attached to the shaft 152.

Polishing liquid to be supplied to the polishing member is selected from pure water, a chemical liquid, a slurry, and the like. If desired, two or more types of polishing liquids may be supplied simultaneously, alternately or in a predetermined order.

In order to protect a mechanism for effecting a circular

orbital motion from damage by polishing liquid during polishing, a flinger 169 is attached to the polishing table 35 and, together with a gutter 170, provides a labyrinth mechanism.

In the above-mentioned arrangements, the polishing table 35 is subject to a circular orbital motion by operation of the motor 150, and wafer W held by wafer holder 10 (see Fig. 1) is pressed against polishing surface 1a of the polishing member 1 on the polishing table 35.

Polishing liquid from a polishing liquid supply nozzle (not shown) is supplied to the polishing surface 1a of the polishing member 1, and polishing of the wafer W is conducted. A minute relative circular orbital motion with radius "e" is generated between the polishing surface 1a and the wafer W, and a relative velocity between the polishing surface 1a and the wafer W is generated uniformly over the polishing surface in its entirety. Therefore, the wafer W can be polished uniformly over its entire surface to be polished. It is to be noted that if a positional relationship between a wafer surface and the polishing surface 1a is the same, local differences in the polishing surface 1a exert an undesirable influence on polishing. Therefore, the wafer holder 10 is gradually rotated about its axis, so as to prevent the wafer surface from being polished only at the same position on the polishing surface 1a. In the polishing member 1 used for this polishing table which is subject to a circular orbital motion, the same effects as those in the case of Figs. 1 and 2 can be obtained.

Next, referring to Figs. 6 and 7, shown is a semiconductor

processing apparatus which comprises the polishing apparatuses shown in Figs. 1 through 5(b) and a cleaning apparatus.

Recently, as a semiconductor processing apparatus in which a wafer is polished by Chemical Mechanical Polishing, a so-called dry-in/dry-out system has been employed, in which a semiconductor wafer is loaded into the apparatus in a dry state and unloaded in a dry state. Illustratively stated, in the dry-in/dry-out system, a semiconductor wafer is loaded into the apparatus in a dry state, and polished. After polishing is complete, particles are removed from the wafer by a cleaning unit. Then, the wafer is dried by a spin-dry unit and unloaded from the apparatus in a dry state. Fig. 6 is a plan view showing an entire construction of a dry-in/dry-out semiconductor processing apparatus. Fig. 7 is an elevational view of the semiconductor processing apparatus of Fig. 6. As shown in Fig. 6, the semiconductor processing apparatus includes four loading/unloading stages 52 on which wafer cassettes 51 are loaded. The wafer cassettes 51 are adapted to store a number of semiconductor wafers. The loading/unloading stages 52 may include a lift mechanism. A transfer robot 4 having two hands is disposed on a travelling mechanism 53 so that the robot can reach each of the wafer cassettes 51 on the loading/unloading stages 52.

Two cleaning machines 55 and 65 are disposed in symmetric relation relative to the wafer cassettes 51, with respect to the travelling mechanism 53 for the transfer robot 4. The cleaning machines 55 and 65 are positioned within reach of the hands of the transfer robot 4. A wafer station 48 having four wafer mounts 7, 8, 9 and 19 is disposed between the cleaning machines 55 and

65, and within reach of the transfer robot 4. The cleaning machines 55 and 65 also function to spin-dry a wafer by subjecting it to high-speed rotation. Therefore, no modular exchange is required in the apparatus for adaptation to a two-stage cleaning operation or a three-stage cleaning operation.

A partition wall 14 is provided to provide different levels of cleanliness between a region A in which the wafer cassettes 51 and the transfer robot 4 are disposed, and a region B in which the cleaning machines 55 and 65 and the wafer mounts 7, 8, 9 and 19 are disposed. A shutter 11 is provided at an opening formed in the partition wall 14 for transfer of a wafer between region A and region B. A transfer robot 32 having two hands is disposed at a position such that it can reach the cleaning machine 55 and the three wafer mounts 7, 9 and 19; and a transfer robot 33 having two hands is disposed at a position such that it can reach the cleaning machine 65 and the three wafer mounts 8, 9 and 19.

The wafer mount 7 is used for transferring a wafer between the transfer robot 4 and the transfer robot 32. The wafer mount 8 is used for transferring a wafer between the transfer robot 4 and the transfer robot 33. The wafer mount 9 is used for transferring a wafer from the transfer robot 33 to the transfer robot 32, and the wafer mount 19 is used for transferring a wafer from the transfer robot 32 to the transfer robot 33.

A cleaning machine 22 is disposed adjacent to the cleaning machine 55 so that the hands of the transfer robot 32 can reach the cleaning machine 22. A cleaning machine 23 is disposed adjacent to the cleaning machine 65 so that the hands of the

transfer robot 33 can reach the cleaning machine 23.

The cleaning machines 55, 65, 22 and 23, the wafer mounts 7, 8, 9 and 19 of the wafer station 48, and the transfer robots 32 and 33 are disposed within region B. A pressure in region B is set to be lower than that in region A. The cleaning machines 22 and 23 are capable of cleaning both surfaces of a wafer.

Elements of the semiconductor processing apparatus of Fig. 6 are enclosed in a housing 46. The housing 46 is divided into a plurality of chambers (including regions A and B) by the partition wall 14, a partition wall 15, a partition wall 16, a partition wall 24 and a partition wall 47.

A polishing chamber is separated from region B by the partition wall 24, and divided into two regions C and D by the partition wall 47. Each of regions C and D contains the polishing table 5 shown in Fig. 1, which is rotated about its axis, and the polishing table 35 shown in Fig. 4, which is subject to a circular orbital motion. The polishing member 1 such as is shown in Fig. 2 is attached to each of upper surfaces of the polishing tables 5 and 35. The polishing member 1 on the polishing table 5 comprises a polishing pad, and the polishing member 1 on the polishing table 35 comprises an abrasive plate having fixed abrasive particles. Further, each of regions C and D contains a single wafer holder 10 which holds one wafer and presses it against the polishing tables 5 and 35 for polishing, polishing liquid supply nozzle 21 for supplying a polishing liquid to the polishing table 5, dresser 20 for conducting dressing of the polishing table 5, and a dresser 50 for conducting dressing of

the polishing table 35.

Fig. 7 is an illustration showing a relationship between the wafer holder 10 and the polishing tables 5 and 35. As shown in Fig. 7, the wafer holder 10 is suspended from a wafer holder head 31 through a wafer holder drive shaft 91 capable of rotation. The wafer holder head 31 is supported by a pivot shaft 92 capable of being positioned. By pivotally moving the pivot shaft 92, the wafer holder 10 can be moved to the polishing tables 5 and 35 and a rotary transporter 27 (described later). Dresser 20 is suspended from a dresser head 94 through a dresser drive shaft 93 capable of rotation. The dresser head 94 is supported by a pivot shaft 95 capable of being positioned. By pivotally moving the pivot shaft 95, the dresser 20 can be moved between its stand-by position and a dressing position on the polishing table 5. Each of the polishing table 5 and the dresser 20 is adapted to rotate about its axis.

Referring back to Fig. 6, dresser 50 in an elongated form is subject to a parallel motion along an upper surface of the polishing table 35 which is subject to a circular orbital motion, to thereby dress polishing surface 1a of polishing member 1 on the polishing table 35.

In region C separated from region B by partition wall 24, a turning-over machine 28, which turns a wafer over, is disposed within reach of the hands of the transfer robot 32, and a turning-over machine 28′, which turns a wafer over is disposed within reach of the hands of the transfer robot 33. The partition wall 24 dividing region B and region C includes openings through

which wafers are passed. Shutters 25 and 26 used for the turning-over machines 28 and 28′, respectively, are provided at these openings.

The rotary transporter 27 is disposed below the turning-over machines 28 and 28′ and the wafer holder 10, to transfer a wafer between a cleaning chamber (region B) and the polishing chamber (regions C and D). The rotary transporter 27 includes four equal stages on which wafers are loaded. By this arrangement, a plurality of wafers can be loaded on the rotary transporter 27 at the same time. When a phase of a center of a wafer held by the turning-over machine 28 or 28′ coincides with that of a center of one stage of the rotary transporter 27, a lifter 29 or 29′ disposed below the rotary transporter 27 is moved upwardly, to thereby transfer the wafer onto the stage of the rotary transporter 27. The wafer on the stage of the rotary transporter 27 is then transferred to a position below one wafer holder 10, by rotating the rotary transporter 27 through 90°. At this time, the wafer holder 10 has already been moved to a position above the rotary transporter 27. When a phase of a center of the wafer holder 10 coincides with that of a center of the wafer on the rotary transporter 27, a lift 30 or 30′ disposed below the wafer holder 10 is moved upwardly, to thereby transfer the wafer from the rotary transporter 27 to the wafer holder 10.

The wafer holder 10, which has a mechanism for producing a vacuum, holds the wafer under influence of a vacuum. The wafer is then transferred to the polishing table 5 while it is held on the wafer holder 10. Then, the wafer is polished by the polishing

member 1 (comprising a polishing pad) attached to the polishing table 5. The polishing table 35, as a second polishing table adapted to be subject to a circular orbital motion, is disposed within reach of the wafer holder 10. Therefore, a wafer which has been polished at the polishing table 5 can be further polished by polishing member 1 comprising an abrasive plate attached to the polishing table 35. Polishing may be first conducted at the polishing table 35 and then conducted at the polishing table 5, depending on a type of a film formed on a wafer. In this case, because the polishing surface of the polishing table 35 has a small diameter, running costs can be reduced by roughly polishing a wafer surface using the polishing member 1 comprising an abrasive plate on the polishing table 35, which abrasive plate is more costly than a polishing pad, and then subjecting the wafer to a finishing polish using the polishing member 1 comprising a polishing pad on the large-diameter polishing table 5, which polishing pad is less durable than an abrasive plate.

By providing a polishing pad on the polishing table 5 and an abrasive plate on the polishing table 35, costs of the polishing tables can be reduced. This is so because cost of an abrasive plate is higher than that of a polishing pad, and increases in proportion to a diameter of the abrasive plate. Further, the life of the polishing pad, which pad is less durable than the abrasive plate, can be increased by using the pad for a finishing polish, which is conducted under a low load. Further, when a polishing pad has a large diameter, a frequency of contact between the pad and a wafer can be distributed, thus increasing

the life of the polishing pad. Therefore, a cycle of maintenance can be extended and productivity of the apparatus can be increased.

After the wafer has been polished by the polishing table 5 (or the polishing table 35), the wafer holder 10 is separated from the polishing table 5 (or the polishing table 35) and, before the wafer holder 10 moves to the polishing table 35 (or the polishing table 5), a cleaning liquid is ejected from a cleaning liquid nozzle (not shown), disposed adjacent to the polishing table 5 (or the polishing table 35), toward the wafer held on the wafer holder 10. Thus, the wafer is rinsed before being moved to the polishing table 35 (or the polishing table 5); and in this way, migration of contaminants between the polishing tables can be prevented.

Next, description is made with regard to a route for transferring a wafer during an operation conducted in the apparatus of Fig. 6. A two-cassette parallel operation is provided as an example.

That is, a route for transferring one wafer is as follows:

wafer cassette 51 → transfer robot 4 → wafer mount 7 of wafer station 48 → transfer robot 32 → turning-over machine 28 → a loading stage of rotary transporter 27 → wafer holder 10 → polishing table 5 (or polishing table 35) → polishing table 35 (or polishing table 5) → an unloading stage of rotary transporter 27 → turning-over machine 28 → transfer robot 32 → cleaning machine 22 → transfer robot 32 → cleaning machine 55 → transfer robot 4 → wafer cassette 51.

On the other hand, a route for transferring another wafer is as follows:

wafer cassette 51 → transfer robot 4 → wafer mount 8 of wafer station 48 → transfer robot 33 → turning-over machine 28′ → a loading stage of rotary transporter 27 → wafer holder 10 → polishing table 5 (or polishing table 35) → polishing table 35 (or polishing table 5) → an unloading stage of rotary transporter 27 → turning-over machine 28′ → transfer robot 33 → cleaning machine 23 → transfer robot 33 → cleaning machine 65 → transfer robot 4 → wafer cassette 51.

As has been described above, in the present invention, a pumping action is produced at the spiral grooves under a centrifugal force generated by rotation of the polishing member, and harmful large-diameter particles such as diamond particles from a dresser and abrasive particles in a polishing liquid can be discharged, together with the polishing liquid, through the spiral grooves toward an outer peripheral portion of the polishing member. This prevents scratches from being formed on a wafer surface, and enables the wafer surface to be engaged with the polishing member under a uniform pressure, thereby obtaining a stable polishing performance.

Further, a polishing liquid in a slurry form can be stably supplied to a wafer surface through the spiral grooves. This further enhances a stable polishing performance.

Further, a polishing surface is subject to atmospheric pressure acting through the spiral grooves, and thus no strong adhesive force acts on a wafer. Therefore, the wafer can be

reliably removed from the polishing surface and transferred, without being damaged.

Fig. 10 shows a polishing apparatus according to a further embodiment of the present invention. In this polishing apparatus, a polishing member 201 comprising two layers and having spiral grooves 202 is provided on a turntable 205. The polishing member 201 comprises a porous Teflon pad 201a adhered to an upper surface of the turntable 205, and a polishing member 201b provided on the pad 201a and having the spiral grooves 202 formed therein. Arrangement of the polishing member 201b is the same as those of the polishing members shown in the above-mentioned embodiments.

In this embodiment of Figs. 10 and 11, a liquid sump 205a is formed at a center of the upper surface of the turntable 205, and passages 205b are formed so as to radially extend from the liquid sump 205a. The liquid sump 205a is communicated with a source of supply of an abrasive liquid through a passage extending through a center of a rotary shaft 252 for the turntable 205. When the turntable 205 is rotated by a motor 250, an abrasive liquid is supplied to the liquid sump 205a and flows in a radial direction through the passages 205b, under a centrifugal force generated by rotation of the turntable 205. The abrasive liquid reaches an upper surface of the porous Teflon pad 201a through pores formed in the pad. The abrasive liquid then penetrates the polishing member 201b and is supplied to an upper polishing surface of the polishing member. The passages 205b may be arranged in spiral form as in the case of the spiral grooves.

In this embodiment, by using a water-repellent Teflon pad, an abrasive liquid can be smoothly and uniformly supplied to the polishing member. When excessively large abrasive particles are contained in the abrasive liquid, they are filtered off from the liquid when the liquid passes through the Teflon pad. This prevents scratches from being formed on a wafer surface due to excessively large abrasive particles in the abrasive liquid. In the above-mentioned embodiments in which an abrasive liquid is supplied from an upper position relative to a polishing member, an abrasive liquid in an excess amount is supplied and discharged to an exterior, thus wasting the abrasive liquid. In this embodiment of Figs. 10 and 11, however, an abrasive liquid can be supplied without waste.

The embodiment shown in Figs. 10 and 11 can be modified by arranging spirally grooved polishing member 201 as a single layer having no Teflon pad.

Fig. 12 shows a further embodiment of the present invention. In this embodiment, use is made of a polishing member 260 comprising a single layer and having spiral grooves formed therein. A liquid sump and passages radially extending therefrom, which are formed in the turntable 205 in the embodiment of Figs. 10 and 11, are formed in the polishing member 260 in this embodiment (the passages are indicated by 262). Further, passages 264 are formed between the passages 262 and the spiral grooves 202 so as to allow passage of abrasive liquid between the passages 262 and the grooves 202.

Fig. 13 is a plan view of a polishing member 270 having

spiral grooves formed therein, according to a further embodiment of the present invention. Specifically, the polishing member 270 includes passages 274 extending in a generally radial direction so as to connect adjacent spiral grooves 272. By this arrangement, discharge of particles generated from a wafer to an exterior during polishing, which is effected through the spiral grooves, can be efficiently conducted.

Figs. 14 and 15 show a polishing member 301 having an indicator 306 provided in spiral grooves 302. The indicator 306 indicates that the spiral grooves 302 have reached a limit of their appropriate depth as a result of polishing. The indicator 306 is imparted with a color different from that of the polishing member. In the example of Fig. 14, the indicator 306 is provided only at a bottom of an outermost spiral groove 302. In the example of Fig. 15, a plurality of indicators 306 are provided at bottoms of all the spiral grooves 302. By this arrangement, an extent to which the polishing member is polished, and hence an extent to which the spiral grooves are polished, can easily be observed.

ABSTRACT OF THE DISCLOSURE

A polishing member is provided in its polishing surface with a plurality of spiral grooves. The polishing surface is rotated while being slidably engaged with a semiconductor wafer to polish the wafer. During polishing, a pumping action is produced at the spiral grooves under a centrifugal force generated by rotation of the polishing member, and harmful large-diameter particles such as diamond particles from a dresser, and abrasive particles in a polishing liquid, can be discharged, together with the polishing liquid, through the spiral grooves toward an outer peripheral portion of the polishing member.